

A LASER WELDING HEAD-CONTROLLING SYSTEM,  
A LASER WELDING HEAD AND A METHOD  
FOR CONTROLLING A LASER WELDING HEAD

Background of the Invention

1) Field of the Invention:

This invention relates to a laser welding head-controlling system, a laser welding head and a method for controlling a laser welding head.

5 2) Description of Related Art:

A laser welding technique is suitable for fabricating an ultrahigh-vacuum apparatus composed of high precise processed parts made of a steel material. Recently, in the laser welding technique, a YAG (yttrium-aluminum-garnet) laser is widely used. The welding technique using the  
10 YAG laser has the following advantages: First, since the laser beam from the YAG laser is absorbed to parts to be welded of members to be welded made a metallic material effectively, the welding process can be carried out efficiently. Second, since the laser beam can be transmitted by an optical fiber, the laser welding head can be mounted on a three-dimensional welding apparatus or a  
15 steel-collar worker. Third, since a condenser and a laser beam-penetrating window can be made of quartz, they are safe at their destruction and can made in low cost.

On the other hand, the laser welding technique requires high precision in positioning the laser beam spot for realizing a high precise  
20 welding process. The latitude of the positioning operation is within 10% of the thickness of the members to be welded or 50% of the spot diameter of the laser beam. Since the spot diameter of the above laser beam is generally 1 mm or below in the welding process, the positioning precision of not more than 0.2 mm is required if the focused spot diameter is about 0.5 mm.  
25 Therefore, in this case, the welding laser head is controlled and traced along a

welding line (seam line) so that the laser beam can be irradiated onto the parts to be welded at a precision of not more than 0.2 mm.

For realizing the above precise welding operation, parts constituting the laser welding head are made precisely, and positioning jigs and  
5 positioning sensors are mounted on the laser welding head.

However, the above conventional laser welding head becomes large in size and high in cost since it has the above complicate structure.

Moreover, a welding process using a CCD camera has been studied and suggested. In the welding process, the laser welding head is traced  
10 along a seam line on the monitored image by the CCD camera. However, as of now, the welding process is not generally employed because the CCD camera does not represent sufficient resolution.

In the case of joining the members to be welded densely, the space between the members becomes almost zero, so that the CCD camera can not  
15 detect the space as light and shade images. Moreover, since, for shortening the image processing period, an input image having 256 black and white gradations is needed, it may suffer from light reflection and flaws on the surfaces of the members to be welded made of a metallic material.

Although it is tried in many field to perform the welding process  
20 and the image processing at real time, the image processing is generally carried out prior to the welding process due to the slow image processing speed and the high welding process speed. That is, as of now, it is impossible to perform the welding process and the image processing at real time.

Moreover, since the welding process using the CCD camera  
25 requires a given space between the CCD camera and the members to be welded for monitoring the welding state of the members, the laser welding head having the CCD camera can not be downsized.

### Summery of the Invention

It is an object of the present invention to provide a laser welding head-controlling system, a laser welding head and a method for controlling a laser welding head to iron out the above matters.

5 For achieving the above object, this invention is directed at a laser welding head-controlling system comprising:

a laser irradiating body with a laser inlet and a laser outlet,  
plural semiconductor lasers to oscillate plural linear laser beams for measuring a welding state,

10 a CCD camera with a band-pass filter therein to pass through only the reflected linear laser beams to take in, as an image, the measured welding state by the reflected linear laser beams, and

an image processor to process the image of the measured welding state.

Moreover, this invention is directed at a laser welding head  
15 comprising the above laser welding head-controlling system, a laser oscillator to oscillate a laser for welding and a condenser to converge the oscillated laser.

And then, this invention is directed at a method for controlling a laser welding head comprising the steps of:

20 irradiating plural linear laser beams for parts to be welded of members to be welded to measure a welding state from plural semiconductor lasers,  
taking, as an image, the measured welding state by the reflected linear laser beams into a CCD camera,

processing the image of the measured welding state, and  
25 controlling a laser welding head based on the processed data of the image.

According to the present invention, the laser welding head can be downsized and made in low cost. Moreover, the welding process can be

performed precisely and easily by using the downsized and small laser welding head.

The other objects, configurations and advantages will be explained in detail, with reference to the attaching drawings.

5                                      Brief Description of the Drawings

For better understanding of the present invention, reference is made to the attached drawings, wherein

Fig. 1 is a structural view showing a laser welding head-controlling system according to the present invention, and

10                      Fig. 2 is a top plan view showing the state in which a welding process is being carried out onto the members to be welded, according to the present invention.

                                    Description of the Preferred Embodiments

This invention will be described in detail with reference to figures.

15                      Fig. 1 is a structural view showing a laser welding head-controlling system according to the present invention. The laser welding head-controlling system has a laser irradiating body 1 with a YAG laser inlet 5, a YAG laser outlet 6, semiconductor laser apparatus 2 and 3, and a CCD camera 4.

20                      A laser emitted from a YAG laser (not shown) as a laser oscillator provided on a laser welding head is converged by a condenser (not shown), and introduced into the YAG laser inlet 5, and then, emitted from the YAG laser outlet 6 and irradiated onto parts to be welded of members to be welded. The semiconductor laser apparatus 2 and 3, for example, irradiate linear laser beams at an oblique direction of 45 degrees for the parts to be welded, respectively, so that the irradiated laser beams can be orthogonal to the seam line of the parts to be welded. The CCD camera 4 is directed at the parts to be welded to take a photograph of the state of the parts to be welded. The CCD camera 4 has a band-pass filter therein to pass through only the

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above linear laser beams. Therefore, the CCD camera 4 can take the photograph of the state of the parts to be welded by the reflected linear laser beams at the part to be welded without the disturbance of an outside light and a welding laser. The image taken in the CCD camera 4 is transmitted to an image processor (not shown), and is processed in image to determine the distance the between the two linear laser beams, the relative and absolute positions of the two linear laser beams, the line width and the shape of each linear laser beam.

Fig. 2 is a top plan view showing the state in which the welding process is being carried out onto the members to be welded. When two linear laser beams 22 and 23 are irradiated onto the members to be welded, they are disconnected at a seam line 21. When the photograph of the above state is taken by the CCD camera 5, and the thus obtained image is processed, the cross points between the seam line 21 and the line lasers 22, 23 are calculated. If the seam line 21 is linear, the position of the seam line is determined by the cross points. Moreover, due to the oblique irradiation of the line lasers, the inclinations of the parts to be welded are determined by the line widths of the linear laser beams, and the heights of the parts to be welded are determined by the absolute position of each linear laser beam. In this way, the shapes, the inclinations, the heights and the positions of the parts to be welded of the members to be welded and the position of the seam line are determined by the distance between the two linear laser beams, the relative and the absolute positions of the two linear laser beams, and the line width and shape of each linear laser beam.

In the welding process using the laser welding head, it is desired that the shapes and sizes of the parts to be welded of the members to be welded are calculated and monitored by their CAD data and the absolute position and angle of the parts to be welded are monitored by the above image-processing.

In this case, the laser welding head is controlled so as to trace the seam line on the monitored data. The use of the CAD data enables the image introduced from the CCD camera 4 to be precisely processed at a high speed. As a result, the welding process period is shortened, and more, the reproducibility and reliability of the welding process can be developed. Therefore, if at least one of the members to be welded has a complicate shape such as a sphere shape or a cylindrical shape, they can be precisely welded each other.

Although the present invention was described in detail with reference to the above examples, this invention is not limited to the above disclosure and every kind of variation and modification may be made without departing from the scope of the present invention. For example, on the above monitored data, welding defects can be monitored. Moreover, three or over line laser may be employed in the above operation.